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Inverse scattering and GPR data processing: an Introduction

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This abstract is meant to propose a brief overview of the book “Introduction to Ground Penetrating Radar: Inverse scattering and data processing”, edited by Wiley Press (ISBN 9781118305003). The reason why I propose this contribution is the fact that, in spite of the large relevant literature, to the best of my knowledge it is not very common to find a text entirely devoted to the physical-mathematical aspects (a part of them, of course) of GPR data processing. Also due to this, probably a sort of gap between the GPR practice and the underlying theory has been created, and indeed we can meet practitioners convinced that the quality of the achieved results is indefinitely improvable by making narrower the spatial step of the data, or that it is desirable to have extremely directive antennas because this would improve the resolution. In order to provide a work hopefully able to address these and other aspects and hopefully able to give a contribution to the correction of these imprecise beliefs, a dealing from the beginning has been proposed, i.e. a sequential, relatively plane, and as much as possible self consistent, dealing starting from the Maxwell’s equations and reaching the most commonly exploited migration formulas and linear inversion algorithms, both within a 2D and a 3D framework. This follows the didactic aim to provide to the reader an insight about what can be reasonably achieved and what should be reasonably done in the field and during the processing phase in order to achieve satisfying results. In particular, the reader will be hopefully made aware not only of the mathematical passages, but also of the involved approximations, the needed assumptions and the physical limits of the final algorithms. The results have been also back-upped with numerical exercises and with some experimental tests, all of which conceived on purpose for this text, and some questions with the relative answers have been inserted at the end of many chapters. On the other hand, it seemed also well advised to stress the fact that, within a GPR prospecting, the main involved parameters (especially the propagation velocity of the electromagnetic waves in the soil) and the same useful datum, i.e. “the scattered field”, in most cases have to be worked out from the same GPR data. In particular, usually we don’t have the possibility to measure apart the “incident field” and then retrieve the scattered field by means of an immediate subtraction operation. Indeed, these aspects are an intrinsic part of the GPR data processing, and should not left out from a text on this topic. In the end, GPR data processing has its own specificities within the larger framework of the inverse scattering problems, and the book has tried to put into evidence this fact too.
Finally, even if this text is not focused on electronics, it was important to account for the fact that there are two categories of GPR systems, namely those working in time domain and those working in frequency domain. This implies some consequences in terms of the parametric choices in order to gather and process correctly the data, which has been devoted some attention too.
The main aim of the book is to resume and gather together things mostly already known, but usually spread within different texts and contexts, often dealt with different approaches and expressed, let say, with different languages. The book is mainly thought of for Ph.D. students, students of master courses and university students at their last year in geophysics end engineering, but it is accessible to any GPR user with some minimal basis (i.e. at university level) on electromagnetism.
Some small research work has been performed too, as e.g. with regard to the calculation in closed form of the Hermitian images for stepped frequency systems, or with respect to the introduction of the effective maximum view angle, or in order to propose a new plane demonstration of the ill-posedness of the problem.
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